NEW DEVELOPMENTS IN FERTILIZER PLACEMENT RESEARCH

by
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The research program dealing with fertilizer placement is only one phase of the present extensive investigations pertaining to the utilization of commercial plant food. These investigations have been materially expanded and coordinated during the past year, which is an advance in agricultural research believed to be amply justified because of the inevitable increased use of commercial fertilizer and the relatively low fertilizer efficiency apparently obtained from the large tonnage now consumed. Although much intensive work on various phases of the problem is in progress particular attention has recently been directed toward such considerations as fertilizer ratios and reactions, symptoms of malnutrition in plants, rapid methods of determining soil deficiencies, and most effective methods of fertilizer application.

Placement of fertilizer became an essential factor with the introduction, a few years ago, of more readily soluble plant food materials with which well defined methods of application were required to avoid possible early injury to the seed or seedling. Extensive investigations of machine placement of fertilizers were inaugurated largely through the influence of the National Joint Committee on Fertilizer Application composed of representatives of five parent organizations. The organization of the joint committee, of which Professor C.O. Reed of this society is general chairman, was recently described in the April issue of Agricultural Engineering and the March issue of the Fertilizer Review. Because of the complex nature of the fertilizer application problem, and the numerous interrelated factors and conditions involved, research studies are conducted very largely by cooperative effort of the various agencies concerned.

Experiments have also been widely distributed in order that the scope of present fertilizer application practice might be covered to an appreciable extent. In one area or another commercial plant food is now supplied to practically every crop grown in the United States and applied on all major types of soil. The amount of fertilizer ordinarily used varies widely with different crops and existing conditions and ranges from less than 100 to more than 6000 pounds per acre. It has been reliably estimated that the consumption of commercial fertilizer on more than two million farms throughout the United States during 1936 will closely approach 7,000,000 tons, with a value of approximately $175,000,000.

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Fertilizer placement experiments on which reports have been presented to the Joint Committee were conducted during the past year with 13 crops at 49 locations in 16 states. The following agencies formally cooperated in this experimental work: The U.S. Bureaus of Agricultural Engineering and Plant Industry, The National Joint Committee on Fertilizer Application, The National Fertilizer Association, and Agricultural Experiment Stations in Georgia, Indiana, Louisiana, Maine, Maryland, Michigan, Mississippi, New Jersey, New York, North Carolina, Ohio, Oklahoma, South Carolina, Texas, and Virginia. Progress reports presenting the findings of the various studies in considerable detail have been assembled in the Proceedings of the Eleventh Annual Meeting of the National Joint Committee on Fertilizer Application, which was published and distributed by the National Fertilizer Association, Washington, D.C. The above mentioned research program does not include a number of independent studies directly related to methods of fertilizer application. As a further review of the developments in mechanical placement of fertilizers which were reported in the October, 1935, issue of Agricultural Engineering, this paper will be confined to a discussion of the new research studies and other activities of the past year.

The results of the 1935 experiments in general indicate that fertilizer is of greatest benefit to the crop when applied in a band at each side of the row. A placement approximately 2 inches to the side of the seed or plant and about 3 inches below the surface of the ground was the superior treatment in most cases. The most effective location of the fertilizer band at the side of the row differed somewhat with the crop, soil and weather conditions, and the amount of fertilizer. Fertilizer placed directly under the seed or plant, either in a band or mixed with the soil, in most cases caused early injurious effects which were reflected in the yields. Fertilizer applied broadcast in a limited number of experiments was in all instances decidedly inferior to comparable placements at the side of the row. These general trends are in line with those observed in the preceding studies.

Methods of fertilizer application for several crops - including corn, cotton, and potatoes - have been studied for several years and the findings are doubtless known to most agricultural engineers. In discussing the more recently inaugurated studies some typical results on an acre basis will be given to show the magnitude of crop differences obtained in 1935 with representative fertilizer placements. Fertilizer placement, unless otherwise mentioned, indicates the amount of fertilizer-free soil interposed between the fertilizer and the seed or plant.

At Geneva, New York, the highest yield of wax beans was 3,898 pounds with 300 pounds of fertilizer placed in a band 1.5 inches to each side of the seed and only 2,706 pounds with the same amount of fertilizer placed 2 inches under the seed. Double the amount of fertilizer applied broadcast gave 3,040 pounds of beans. The results definitely indicate that broadcasting fertilizer in farm practice un-

der these conditions would result in exceptionally low fertilizer efficiency. The same relative standing of treatments and similar crop differences were obtained with lima beans at Norfolk, Virginia. No conclusive trends were noted in studies with white beans in Michigan under the existing conditions except the adverse effects of fertilizer when placed in the furrow with the seed.

Investigations have indicated that yields of transplanted crops differ materially according to the placement of the fertilizer. The average yields of tobacco for three experiments located at Tifton, Georgia; Florence, South Carolina; and Oxford, North Carolina were valued as follows: Local practice, of drilling the fertilizer in the row, mixing with the soil, and ridging, $301; fertilizer placed in a band 2.5 inches to each side of the row, $331; a band 1 inch under the plant, $216; mixed with the soil in the root zone, $268; and placement at the sides of the row, but two-fifths of the fertilizer being applied 3 weeks after transplanting, $351. A precise placement of the fertilizer in a band at each side of the row, whether the entire application is made at time of setting the tobacco plants or a portion of the fertilizer is applied as a side dressing, appears to be of definite advantage. The highest yields of both cabbage and tomatoes were produced with fertilizer placed 2.5 inches from the row, in experiments in New York and Virginia where methods similar to those with tobacco were employed. The possibilities of further increasing fertilizer efficiency were indicated with tomatoes at Geneva, New York, where hill applications in a 15-inch band at each side of the plant produced 4 per cent larger yields than did continuous bands.

Previous fertilizer placement studies have been confined to the more widely spaced row crops. Experiments inaugurated the past year with cannery peas and spinach are of particular interest because these crops are grown in closely spaced rows. The experiment with cannery peas was conducted at Geneva, New York, where the grain drill is commonly used to plant the seed and the fertilizer is ordinarily applied in the furrow with the seed. The results of this experiment have been published in New York State Agricultural Experiment Station Bulletin Number 659. Under the conditions of this experiment with a 7-inch row spacing, 300 pounds per acre of a 4-16-4 fertilizer applied in the furrow with the seed seriously reduced the stand of plants which resulted in a yield of 935 pounds of vined peas per acre. A yield of 2,246 pounds was obtained without fertilizer. Yields from applications in a band at one side of the row were as follows, according to the horizontal distance from the center of the row to the center of the fertilizer band: 1.5 inches, 2,401 pounds; 2.5 inches, 2,877 pounds; and 3.5 inches, 2,274 pounds. Precision in placing fertilizer, even in relatively small amounts, to a sensitive crop such as peas evidently is essential.

Marked effects of fertilizer placement on spinach grown at Norfolk, Virginia, in rows spaced 8 inches apart were noted. Germination and seedling growth were greatly retarded where the fertilizer was placed under the seed.

Numerous significant points observed in the studies with the various crops in different states cannot be specifically mentioned in this brief account of recent findings. For example, side placement was superior for cotton and a band of fertilizer at only one side was equally as effective as a band at each side of the row. Hill application of fertilizer for potatoes with the common spacing of the seed pieces showed indications of advantage in certain instances. Placement of fertilizer above the seed as accomplished with certain attachments for grain drills was not advantageous with peas under the prevailing conditions. Residual effect of fertilizer applied the preceding season along widely spaced rows did not cause uneven maturity and inferior quality of cannery peas to which fertilizer was properly applied. With lima beans, residual benefits were greater where fertilizer was previously confined to each row, than where broadcast.

The present research program has brought out a few indications as to why fertilizer is of greatest benefit to the crop when placed in certain definite positions. The trends observed in the experiments conform to logical reasoning based on present knowledge of physical and chemical changes which take place after fertilizer is deposited in the soil. It is beyond the scope of this paper to trace the changes and chemical reactions through their various stages. However, the following general statements of certain effects may be of interest in this connection:

Fertilizer is of little benefit to the crop except in the presence of adequate moisture.

Some seedlings are apparently stimulated by the fertilizer even before they appear above ground, which has been frequently indicated by fewer plants emerging when no fertilizer is applied.

Early injury is caused mainly by too great a concentration of fertilizer salts in the soil solution surrounding the seed or plant roots. The concentration of the soil solution varies inversely with either the amount of soil moisture or the time elapsing after the fertilizer application, and directly with the amount of fertilizer. Experimental results indicate that from ten to twenty days is usually required under average conditions for relatively large amounts of fertilizer to diffuse in the soil to a point where the concentration of the soil solution does not adversely affect the plant. The degree of concentration required to cause injury is not the same for all crops. Some injury may be caused by the toxicity of certain materials.

The soluble fertilizer salts are diffused in the soil as they move with the soil solution. Movement, which is much greater vertically than horizontally, starts immediately if sufficient moisture is present. Due to leaching in loose textured soils, a portion of the soluble fertilizer materials may be carried out of reach of the plant.

Chemical reactions in some soils make certain plant food elements unavailable to the plant. Such reactions are at a maximum when the fertilizer is widely distributed and in intimate contact with the largest possible amount of soil.

In view of the above mentioned processes, fertilizer placed in appreciable amounts in the furrow with the seed, or either closely under or above the seed or seedling roots, is very likely to have some immediate injurious effects. If the soluble fertilizer salts are not carried into contact with the seed, the seedlings, within a few days, will reach the fertilizer whether above or below. Heavy rainfall at the proper time dilutes the soil solution to such an extent that the possibilities of fertilizer injury is materially decreased. On the other hand, severe injury is usually noted with little or no rainfall for 2 or 3 weeks following the fertilizer application.

Mixing of the fertilizer with the soil in the row is hazardous unless the fertilizer is either well distributed around the seed or seedling or is applied a week or two in advance of planting. This method has been very generally used in the past, but without due precaution it is questionable in many cases because of the uncertainty of definite placement of the fertilizer with respect to the seed or seedling. The thoroughness of the mixing depends to a great extent on the condition of the soil and the design of the mixing tools. If the planting of the seed is accomplished in a separate operation the relative placement of fertilizer and seed may not be definitely and uniformly controlled. This method of application when improperly used has frequently resulted in serious early injury to the crop under adverse moisture conditions. Furthermore, placement of fertilizer under the seed at time of planting either in a band or mixed with the soil necessitates depositing the seed in disturbed soil, the capillarity of which is broken. The percentage and rapidity of germination has been lowered in many cases where the seeds were deposited in loose soil.

Fertilizer applied broadcast usually has no serious early adverse effects on the crop, although such effects have been observed in the experimental work with crops of low fertilizer tolerance. Material loss of certain fertilizer elements, particularly phosphorus, through fixation with certain types of soil has been observed with broadcast applications. It is also quite obvious that the possibilities of the leaching of soluble salts would be greatest with broadcast applications. Materials not readily soluble which are applied on or near the ground surface may not be within the reach of the plant until worked into the soil or otherwise covered to a sufficient depth. Root development is often restricted in the surface soil either by lack of moisture or frequent disturbance in cultivating the crop.

Proper placement of fertilizer in a narrow band at either one or both sides of the row whether continuous or in short bands at the hill obviates some of the difficulties encountered with the methods above mentioned. Since the soluble fertilizer salts do not move much laterally, there is practically no possibility of early injury to the seed or seedling. Tap roots, some of which extend downward several inches before the seedling appears above ground, do not encounter a high concentration of fertilizer salts. If the fertilizer is at a depth to insure the presence of adequate soil moisture under usual conditions it will be in the path of the main lateral root system of most crops. By the time the lateral roots reach the fertilizer band the soluble fertilizer has diffused in the soil sufficiently to prevent damage. The possibilities of leaching and of fixation of fertilizer constituents are reduced by confinement of the fertilizer to a limited zone in the soil. Furthermore, it is not necessary to disturb the soil under the seed.

There are exceptions to the above general statements particularly under conditions of heavy rainfall and small applications of fertilizer. No particular fertilizer placement has been invariably the best but certain placements have been rather consistently superior. Some questionable placements not definitely inferior under favorable conditions have resulted in severe crop losses under adverse conditions.

There has been progress toward the development, adoption, and use of improved equipment for advantageous placement of fertilizer. This advancement during the past year, so far as known, has covered very largely the refinement of devices recently developed and the more widespread use of the improved machines. Planting machines equipped to place the fertilizer in a band at the side of the row especially for corn and potatoes have been available for several years but the improved fertilizer placement feature has been given increased attention and adopted more generally. The recent side placement equipment for beans and cotton has been adapted to wider ranges of conditions and is in more general use with considerable evidence of satisfactory results.

Increased attention has been given to side-placement fertilizer depositors for transplanters, on the part of both the farmer and the machinery manufacturers. At least one additional make of transplanter has been equipped during the past year to apply the fertilizer at each side of the row. The equipment is located behind the transplanting unit on the machine and thus deposits the fertilizer after the plants are set.

In farm practice where fertilizer is ordinarily applied in a separate operation different procedures have been more generally followed which result in a side placement of the fertilizer when the seed or plants are deposited. Suitably equipped fertilizer distributors and fertilizing planters with the planting mechanism out of gear, have been used to apply the fertilizer in two parallel bands,

form a bed over the fertilizer and mark the center of the row. Either seed or plants could then be satisfactorily placed between the fertilizer bands. In other instances, the fertilizer is applied in the mark and separate bedding operations are controlled to place the center of the bed 2 or 3 inches to one side of the fertilizer, in which case the planter or transplanter is then centered on the bed as usual.

In certain areas where grain drills are employed to plant crops such as peas which are susceptible to fertilizer injury, there has been considerable demand for equipment to place the fertilizer at the side of the row rather than in the furrow with the seed as ordinarily accomplished with present standard equipment. While certain manufacturers have given this matter some attention, the introduction on the market of drills with such features have not come to my attention.

With regard to various vegetable crops grown in closely spaced rows there have been numerous inquiries concerning planting equipment provided with approved fertilizer depositors. Although some small machines on this order are available, larger multiple-row units commonly used by commercial growers have not been adapted to general farm use. When we consider the operation of closely spaced planting units and the required accurate and shallow covering of many kinds of seeds, it is quite obvious that the use of additional soil working tools to place the fertilizer at the desired depth in the soil would be subject to difficulties not encountered with widely spaced units. However, the mechanical problems are not believed to be unsurmountable. Arrangements whereby small planting units are attached to a bar at the rear of a grain drill, have been devised on the farm and used in quite extensive operations. The fertilizer is applied through the grain drill depositors and the corresponding planting units can be adjusted for the desired relative placement of fertilizer and seed.

A recent development of significance is field demonstrations of the influence on various crops of different methods of fertilizer application. Interest has been stimulated in this activity through a more widespread dissemination of information on fertilizer placement. The extension service in several states has undertaken field demonstrations of approved placements of fertilizer. Demonstrational work has also been carried out and otherwise actively supported by several implement manufacturers. In this connection it might be stated that a particular drill, planter, or transplanter is usually adaptable to the planting of several different crops and the question has been raised as to the feasibility of using the particular fertilizer depositor on each machine for the various crops that might be planted. This question cannot be definitely answered because experimental evidence is available only for a limited number of crops but present trends indicate that such an arrangement might not be particularly objectionable provided the placement selected was in accordance with the findings to date and a satisfactory depth of the fertilizer in the soil could be obtained in all cases irrespective of the depth at which the seed or plants are deposited.

A large number of lines of research endeavor might be pursued in both the fundamental and practical considerations of proper fertilizer use. In addition to following previously inaugurated studies to a logical conclusion, the present fertilizer placement program has been extended to additional crops and conditions. Also the possibilities of increased efficiency by reducing contact of the fertilizer with the soil through hill applications, single bands and larger fertilizer particles are being explored. The National Joint Committee on Fertilizer Application has undertaken a nationwide survey of present fertilizer application practices and of the distributing equipment available. This survey has been divided into four parts which are related but conducted independently. Three parts cover the following groups of crops: field crops, truck crops, and fruits and nuts, while the fourth covers distributing machinery on the market. This survey is well underway and on completion, definite information will be available to serve as a basis for the most intelligent and systematic planning of future activities pertaining to methods of fertilizer application.